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Studies in the genus Gymnosporangium*

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The first systematic study of the genus *Gymnosporangium* as it occurs in America was published by Farlow in 1880 in a paper entitled "The Gymnosporangia or Cedar-Apples of the United States."† European investigators had demonstrated several years earlier ‡ the genetic connection between members of the genera *Gymnosporangium* and *Roestelia*, and it was the desire to study the development of the American species in a similar manner which led to this attempt to define the species morphologically. Such a course was especially necessary because of the variety of forms inhabitating the same host, and the consequent small amount of aid which the host furnished in defining the limits of the various forms or species as they were believed to be. For instance, the earlier artificial cultures in America showed that infection on *Amelanchier* leaves was obtained from the sowing of spores of six apparently distinct species of *Gymnosporangium*, four of which occurred on the red cedar, *Sabina virginiana*. The necessity of following up these cultures and determining whether uniform and recognizable differences were evident in the resulting roestelial forms became at once apparent.

For eleven years, or until 1891, work on this group, by means of anatomical studies supplemented with cultures, was kept up by Farlow and Thaxter. During this period six species of *Gymnosporangium* were successfully connected to their roestelial phase, only one being a repetition of European investigations. The more important results are contained in the following papers: "Notes on some Species of *Gymnosporangium* and *Chrysomyxa* in the United States," by W. G. Farlow; § "The Development of the *Gymnosporangia* of the United States," by W. G. Farlow *; "On certain Cultures of *Gymnosporangium*, with Notes on their *Roesteliae*," by Roland Thaxter †; "Notes on Cultures of *Gymnosporangium* made in 1887 and 1888," by Roland Thaxter ‡; and "The Connecticut Species of *Gymnosporangium* (Cedar Apples)," by Roland Thaxter. § Besides these there have appeared numerous other notes dealing chiefly with the economic importance and genetic connection of certain species, the results serving to confirm the facts given in the papers mentioned.

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* Read before Section G of the American Association for the Advancement of Science, at the Chicago meeting, January 2, 1908.

† Anniv. Mem. Boston Soc. Nat. Hist. 1880.

‡ Bot. Zeit. **23**: 291. 1865; **25**: 222. 1867. Overs. Danske Vid. Selsk. Forh. **1866**: 185–196. *pl. 3, 4.* 1866. Bull. Soc. Roy. Dan. Sci. **1866**: 15, 16. 1866.

§ Proc. Amer. Acad. **20**: 311–328. 1885.

In addition to ascertaining how many valid species existed in this country, the earlier workers met with the difficulty of deciding how many of these they recognized were like those already described in Europe. With a comparatively small number of specimens and those from a limited area in the New England and other eastern states, together with incomplete culture data, it is not a matter of surprise that some wrong references should be made which might later be explained and adjusted, but which, in some instances, have not been so treated up to the present time.

The foregoing is a brief statement of the problems encountered by those who began the systematic study of the genus *Gymnosporangium* in this country, with an abstract summary of the published results. Since the date of the last paper mentioned, 1891, there has been some increase of information concerning the group, and a gradual accumulation of specimens in herbaria, but there is practically no more available fundamental knowledge, in so far as published accounts are concerned.

In taking up the study of the group recently, much difficulty was experienced, therefore, and making headway was slow at first, partly due to the chaotic condition of the data left by the past workers, but due also to the fact that it was insufficient when put into usable form. These difficulties have been met and are being largely overcome, for the present, by the selection of new diagnostic characters, not heretofore employed, and by the detailed study and comparison of a large number of specimens from practically the whole geographical area of the United States and representing nearly all possible ecological conditions. This method of treatment has revealed some undescribed species and the existence of some foreign species not before recognized. In Dr. Dietel's account of the genus *Gymnosporangium* in Engler and Prantl's Natürlichen Pflanzenfamilien in 1897 [*] he ascribed eight species to North America. This account omitted one which was known at that time and should have been included. Two more were described shortly after this work appeared. In a recent paper the writer has described three new forms of *Gymnosporangium* and three of *Roestelia*, all from the Rocky Mountains or the west coast.[†] The present paper characterizes three more forms and includes one foreign species recently reported from this country,[‡] making in all a total of eighteen species under consideration.

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* Bot. Gaz. 11: 234–241. 1886.

† Proc. Amer. Acad. 22: 259–269. 1887.

‡ Bot. Gaz. 14: 163–172. 1889.

§ Bull. Conn. Agric. Exper. Station 107. 1891.

The study of the relationship between the rust species and the host species is now rendered more complicated than it was formerly, owing to the much larger number of rusts recognized on the same number of hosts. In the telial stage, the species of rust, so far as is now known, infest the family *Juniperaceae*, represented by four genera, *Sabina*, *Juniperus*, *Chamaecyparis*, and *Libocedrus*.

On the genus *Sabina* are found twelve species of rust, of which eight inhabit the one host species, *Sabina virginiana*, four of the eight not occurring on any other species of *Sabina*. Four species occur on *Juniperus*, two on *Chamaecyparis*, and one on *Libocedrus*. It is a remarkable fact that each of the *Gymnosporangium* species is confined in the telial stage to a single genus of host plants, with the exception of one, which is reported on both *Sabina* and *Juniperus*, and there is a suspicion that here two species may really exist.

It is a notable fact that in the genus *Gymnosporangium* belong the only rusts which are heteroecious and yet do not possess all spore-forms, the uredinial stage being lacking in all the species. There is known a uredo-form on Juniperaceae from Alaska,[§] however, which may prove a possible exception to the foregoing statement. There is but one collection of it and so little is known that nothing positive can be stated but it seems probable that it should have a telial stage like *Gymnosporangium*, and be heteroecious with a roestelial stage on some of the *Malaceae*.

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[*] E. & P. Nat. Pflanzenfam. 1^{1**}: 50. 1897.

[†] New western species of *Gymnosporangium* and *Roestelia*. Bull. Torrey Club 34: 459–463. 1907.

[‡] The existence of *Roestelia penicillata* and its telial phase in North America. Science II. 27: 931. 1908.

[§] Harriman Alaska Expedition 5: 36. 1904. *Uredo Nootkatensis* Trel. on *Chamaecyparis Nootkatensis*.

Gymnosporangium as a genus is characterized in the telial stage by teliospores having hyaline pedicels, usually of great length, which swell in moisture and often become gelatinized to form a jelly-like matrix in which the spores appear to be imbedded. Of interest in connection with the development of this stage are peculiar distortions which are usually produced either in the leaves or branches.

For the purpose of bringing together the data in such a manner as to be of material assistance in the determination of specimens, a key, involving the more evident diagnostic characters of the telia of the known North American species, and indicating the hosts for each one, is presented herewith. Preceding the key, notes are given for some of the species, explanatory of nomenclature, important extensions in range, and other interesting features which have been revealed in these investigations.

GYMNOSPORANGIUM BERMUDIANUM (Farl.) Earle, in Seym. & Earle Econ. Fungi *249*. 1893

This is the most curious of all the species of *Gymnosporangium*, being the only one which is not heteroecious. The aecial stage is a geniune *Roestelia*, developing in the fall on small, irregular, globoid galls, and is followed in the spring by telia on the same galls. The telia are very inconspicuous and may be easily overlooked in the dried condition of herbarium specimens.

GYMNOSPORANGIUM JUNIPERI-VIRGINIANAE Schwein. Schr. Nat. Ges. Leipzig **1**: *74*. 1822

The name *Gymnosporagium macropus* Link (Willd. Sp. Pl. **6**: 128) is often used in referring to this species but as it was published in 1825, the one established by Schweinitz in 1822 must be accepted as the valid name.

Gymnosporangium floriforme Thaxter, sp. nov.*

Pycnia epiphyllous, numerous, gregarious, on discolored spots, punctiform, honey-yellow becoming blackish, subglobose, 150–175 μ in diameter.

Aecia hypophyllous, rather widely separated in oblong-annular groups 2–6 mm. across, on discolored spots, at first cylindrical, 1–1.5 mm. high, 0.2–0.5 mm. in diameter; peridium soon becoming finely fimbriate and strongly revolute; peridial cells long and narrow, 10–14 μ x 65–85 μ, becoming curved when wet; aeciospores angular-ellipsoid, 18–23 μ x 23–29 μ; wall chestnut-brown, 1.5–2.5 μ thick, finely verrucose; germ pores 6–8, scattered.

On *Crataegus spathulata* Michx., Auburn, Lee County, Alabama, October 21, 1897, *F. S. Earle & C. F. Baker;* October, 1897 *F. S. Earle* (in Sydow, Uredineen no. *1194*); October (year not given) *G. F. Atkinson;* Hot Springs, Arkansas, September 3, 1897, *Wm. Trelease.*

Telia scattered on globose or reniform galls, conical or cylindrical-acuminate, becoming 3–10 mm. long, 1-1.5 mm. wide, chestnut-brown becoming yellowish and pulverulent by germination, surrounded by the ruptured epidermis; teliospores 2-celled, narrowly ellipsoid, 15–19 μ by 39–50 μ, rounded both at apex and base, slightly or not constricted at the septum; wall pale cinnamon-brown, 1–1.5 μ thick, smooth; pedicel hyaline, very long, 3–6 μ in diameter; germ pores 2, near the septum.

On *Sabina virginiana* (L.) Antoine (*Juniperus virginiana* L.), Auburn, Lee Co., Alabama, March 11, 1897, *F. S. Earle* (type);

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* Pycniis epiphyllis, numerosis, in greges dispositis, maculis decoloratis insidentibus, punctiformibus, melleo-flavis, demum atrescentibus, subglobosis, 150–175 μ diam.

Aeciis hypophyllis, in greges oblongo-annulatos 2–6 mm. diam. laxe dispositis, maculis decoloratis insidentibus, primo cylindraceis, 1–1.5 mm. altis, 0.2–0.5 mm. diam.; peridio mox multifido-fimbriato, fimbriis multum revolutis; cellulis peridii longis et angustis, 10–14 μ × 65–85 μ, humidis flectentibus; aeciosporis angulato-ellipsoideis, 18–23 μ × 23–29 μ; episporio castaneo-brunneo, 1.5–2.5 μ crasso, subtiliter verruculoso; poris germinationis 6–8, sine ordine dispersis.

In foliis *Crataegi spathulatae* in Alabama et Arkansas.

Teliis in caespites globosos vel reniformes dispersis, conoideis vel cylindrico-acuminatis, demum 3–10 mm. longis, basi 1–1.5 mm. latis, castaneo-brunneis dein aurantiacis et pulverulentis, epidermide rupta cinctis; teliosporis uniseptatis, angusto-ellipsoideis, 15–19μ × 39–50μ, apice et basi rotundatis, medio non v. vix constrictis; episporio dilute cinnamomeo-brunneo, 1–1.5μ crasso, levibus; pedicello hyalino, longissimo, 3–6μ diam.; poris germinationis binis juxta septum instructis.

In foliis ramulisque *Sabinae virginianae* (*Juniperi virginianae*) Auburn, Lee Co., Alabama, Mar. 11, 1897, *F. S. Earle.*

March 7 and 14, 1896, *Underwood & Earle;* Daytona, Florida, February, 1887, communicated by Dr. Roland Thaxter; Columbus, Mississippi, April 5, 1896, *S. M. Tracy.*

This species is morphologically very similar to *Gymnosporangium Juniperi-virginianae*, but there are some constant differences in the shape of the spore-masses and galls. The spore-masses are darker, shorter, and more conical, while the galls have a peculiar brownish luster. Cultures have been made by Dr. Roland Thaxter at Cambridge, Mass., and by Prof. F. S. Earle at Auburn, Ala., establishing the connection between this and the roestelial form on *Crataegus spathulata.** As a further characteristic, Dr. Thaxter has pointed out in a letter to the writer that it takes this species longer to mature its roestelial form than any other species known to him. The telial stage was fairly well characterized by Underwood and Earle (Bot. Gaz. **27**: 256) in 1896, but no name was employed. In the following year the same authors, in Bull. 80 of the Alabama Experiment Station, p. 218, applied the name *Roestelia flaviformis* without any accompanying description, to the stage on *Crataegus spathulata*, citing Atkinson as an authority. Later, when cultures had proven the connection between the new *Gymnosporangium* on cedar and the *Roestelia* on *Crataegus spathulata*, the combination *Gymnosporangium flaviforme* (Atks.) Earle was made by Earle, *loc. cit.*, without a description. The name *flaviformis* was a misinterpretation of *floriformis*, a herbarium name attached by Thaxter in the Atkinson herbarium.† After consulting with Dr. Thaxter it was decided as preferable to take up the original name *floriforme*. Having furnished notes and specimens and being the author of the name he is cited as the authority.

GYMNOSPORANGIUM CLAVARIAEFORME (Jacq.) DC. Fl. Fr. 2: 217. 1805

This is the most widely distributed of the three European species found in North America, reaching from the Atlantic states into the heart of the Rocky Mountains. The roestelial stage has been known from the western mountains for some time and it has been assumed that the telial stage must also exist there.* Several fine collections made by Professor E. Bethel in Colorado have verified the correctness of this assumption.

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* See Earle, Contr. U. S. Herb. 6 : 186. 1901.

† Farl. Bibl. Index 1 : 44. 1905. "The name *Roestelia flaviformis* given below is a misprint for *Roestelia floriformis*, Thaxter in Herb. Atkinson of which no description has been published. See *Gymnosporangium flaviforme* Earle."

GYMNOSPORANGIUM ELLISII (Berk.) Farl. in Ellis, N. Am. Fungi, *271.* 1879

The connection between this *Gymnosporangium* and *Roestelia transformans* Ellis has been accepted almost without question for many years and there are reasons for believing it correct, but it may be noted that the culture record is much less authoritative than for most of the other species. Cultures were attempted by Thaxter in 1886 and an examination of his report in the Proc. Am. Acad. **22**: 264 shows that as a result of the sowing of the *Gymnosporangium* on detached leaves of *Pyrus* (*Aronia*) *arbutifolia*, an effect was said to be manifest in about eight days on the *Pyrus* leaves but no roestelial form or even pycnia ever developed. So far as the writer knows, this is the only published account referring to cultures of this species.

GYMNOSPORANGUM SPECIOSUM Peck, Bot. Gaz. **3**: 217. 1879

Although this species has been recognized for a good many years all attempts to connect an aecial form with it have failed. There is in its region no unattached species of *Roestelia* known with which it may be associated and there is not the slightest clue as to what the other stage may be.

GYMNOSPORANGIUM JUNIPERINUM (L.) Mart. Fl. Crypt. Erlang. 333. 1817

Under this name is here included the telial form of *Roestelia penicillata* (Pers.) Fries, which has been usually referred to by European writers as *Gymnosporangium tremelloides* Hartig, since he proposed that name in 1882, and not the telial form of *Roestelia cornuta* (Pers.) Fries. A brief statement of this conclusion has been made by the writer in Science **27**: 931. 1908.

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* See Pammel, Bull. Iowa Experiment Station **84**: 32. 1905.

Gymnosporangium germinale (Schwein.) comb. nov.

The full synonymy of this species, which shows that the aecial stage was collected and described many years in advance of the telial stage, is here given.

Caeoma (*Peridermium*) *germinale* Schwein. Proc. Am. Phil. Soc. **4**: 294. 1832.

Peridermium (*Caeoma*) *germinale* Schwein. Proc. Am. Phil. Soc. **4**: 310. 1832.

Podisoma gymnosporangium clavipes C. & P. Jour. Quek. Club **2**: 267. 1871.

Gymnosporangium clavipes C. & P. Ann. Rep. N. Y. State Mus. **25**: 89. 1873.

Roestelia aurantiaca Peck, Ann. Rep. N. Y. State Mus. **25**: 91. 1873.

Puccinia clavipes Kuntze, Rev. Gen. Pl. **3**: 507. 1898.

Tremella clavipes Arth. Proc. Ind. Acad. Sci. **1900**: 135. 1901.

Aecidium aurantiacum Farl. Bibl. Index **1**: 19. Not *A. aurantiacum* Bon. 1860.

Aecidium germinale Arth. Result. Sci. Congr. Bot. Vienne 343. 1906.

Gymnosporangium Botryapites (Schwein.) comb. nov.

This is another instance in which the aecial name is much older than the telial one and becomes the name of the species. The synonymy is as follows.

Caeoma (*Roestelia*) *Botryapites* Schwein. Proc. Am. Phil. Soc. **4**: 294. 1832.

Ceratites (*Caeoma*) *Botryapites* Schwein. Proc. Am. Phil. Soc. **4**: 310. 1832.

Gymnosporangium biseptatum Ellis, Bull. Torrey Club **5**: 46. 1874.

Roestelia Ellisii Peck, Bull. Torrey Club **6**: 13. 1875.

Roestelia Botryapites C. & E. Grevillea **5**: 34. 1876.

Puccinia Botryapites Kuntze, Rev. Gen. Pl. **3**: 608. 1898.

Tremella Botryapites Arth. Proc. Ind. Acad. Sci. **1900**: 135. 1901.

Aecidium Botryapites Farl. Bibl. Index **1**: 22. 1905.

Gymnosporangium Davisii sp. nov.*

Telia chiefly epiphyllous, oval or oblong, 0.7–1 mm. broad, 1–2 mm. long, hemispherical, 0.5–1 mm. high, chocolate-brown, surrounded by the ruptured epidermis; teliospores 2-celled, broadly ellipsoid, 18–28 µ x 40–55 µ, usually narrowed at the base, apex often attenuated, usually furnished with hyaline papillae 4–7 µ thick at the apex and often near the septum in each cell, slightly or not constricted at the septum; wall cinnamon-brown, 1–1.5 µ thick; pedicel hyaline, very long, 3–5 µ in diameter; germ pores one or two, apical or near the septum.

On *Juniperus sibirica* Burgsd. (*Juniperus nana* Willd., *Juniperus communis alpina* Gaud.) Wind Lake, Racine Co., Wisconsin, May 7, 1905 (type), May 22, 1904, *J. J. Davis*; Isle au Haut, Maine, September, 1903, *J. C. Arthur.*

There have been made in this country several collections of this small, inconspicuous form. It is very characteristic and unlike any other so far reported from this country. It occurs chiefly on the leaves, although it may be found sometimes on the smaller stems at the bases of the leaves. The finest specimens are those collected by Dr. J. J. Davis, of Racine, Wis., in the edge of a tamarack swamp near Wind Lake, Racine County, Wis. Unmistakable traces of the same form were found by Dr. J. C. Arthur of Purdue University at Isle au Haut, Maine, but owing to the lateness of the season, it being September when his search was made, no spore-masses remained on the leaves. The spores are readily distinguishable from all other American forms, now known, by the presence of hyaline papillae over the germ pores. In this respect they are very much like the form said to be culturally connected in Europe with *Roestelia cornuta* (Pers.) Fries. However, the American form both at Wind Lake and at Isle au Haut is reported by Drs. Davis and Arthur to be intimately associated with an aecial form on *Aronia*. This *Roestelia* on *Aronia* resembles in general appearance the *Roestelia cornuta* (Pers.) Fries on *Sorbus*, but a microscopical examination shows that it is morphologically distinct. This fact has assisted in arriving at the conclusion that the telial form under discussion is not identical with the one connected to *Roestelia cornuta* on *Sorbus* in Europe, and it is therefore characterized as a new species. It is hoped that cultures may soon be made which will give additional information. In the selection of a name the author has taken the opportunity to show his regard for the valuable services rendered to mycology by Dr. Davis and especially appreciation of his assistance in the study of this species. It may be added here that *Roestelia cornuta* on *Sorbus* occurs in this country but no telial form has ever been found associated with it.

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*Teliis plerumque epiphyllis, ovatis v. oblongis, 0.7–1 mm. latis, 1–2 mm. longis, hemisphaericis, 0.5–1 mm. altis, fusco-brunneis, epidermide rupta cinctis; teliosporis uniseptatis, late ellipsoideis, 18–28 µ × 40–55 µ, basi plerumque angustatis, apice saepe attenuatis, apice et saepe juxta septum in quaque cellula papillis hyalinis 4–7 µ crassis praeditis, medio non v. vix constrictis; episporio cinnamomeo-brunneo, 1–1.5 crasso; pedicello hyalino, longissimo, 3–5 µ diam.; poris germinationis apice v. juxta septum singulis v. binis instructis.

In foliis ramulisque *Juniperi sibiricae* (*Juniperi nanae*), Wind Lake, Racine Co., Wisconsin, Maio 7, 1905, *J. J. Davis.*

Gymnosporangium exiguum sp. nov.*

Telia foliicolous, scattered irregularly, tongue-shaped or conical, small, 0.5–1 mm. thick, 1–1.5 mm. high, chestnut-brown; teliospores 2-celled, ellipsoid, 18–23 μ × 45–55 μ, rounded or slightly narrowed both above and below, slightly or not constricted at the septum; wall cinnamon-brown, about 1.5 μ thick; pedicel hyaline, 5–6 μ in diameter, long; germ pores 2 in each cell near the septum.

On leaves of *Sabina virginiana* (L.) Antoine (*Juniperus virginiana* L.), Fredericksburg, Texas, March, 1895, *F. Grasso.*

On leaves of *Sabina sabinoides* (H.B.K.) Small (*Juniperus sabinoides* Sargent), Austin, Texas, March and April, 1901, *W. H. Long.*

This is a very delicate and inconspicuous species. It somewhat resembles *G. Nelsoni* but differs in its distribution on the host and in the shape of the sori. It differs from *G. inconspicuum* by having slender terete pedicels instead of inflated ones. There is at present no roestelial form recognized from this region which may be associated with this species.

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* Teliis foliicolis, irregulariter dispositis, liguliformibus vel conoideis, parvis, 0.5–1 mm. crassis, 1–1.5 mm. altis, castaneo-brunneis; teliosporis uniseptatis, ellipsoideis, 18–23 μ × 45–55 μ, apice et basi rotundatis vel interdum conico-angustatis, medio non vel vix constrictis; episporio cinnamomeo-brunneo, ca. 1.5 μ crasso; pedicello hyalino, 5–6 μ diam., longo; poris germinationis binis juxta septum instructis.

In foliis *Sabinae virginianae* (*Juniperi virginianae*) Fredericksburg, Texas, Mar. 1895, *F. Grasso.*

Gymnosporangium Libocedri (Henn.) comb. nov.

In 1890 H. Mayr used the combination *Gymnosporangium Libocedri* in his work "Die Waldungen von Nordamerika" but he did not describe the fungus he referred to in such a way as to establish the name. In 1898 P. Hennings described in Hedwigia **37**: 271 a species of rust which he evidently took to be the same as the one Mayr had referred to but named it *Phragmidium Libocedri*. Sydow was the next to study the *Libocedrus* rusts and a full account of his observations is given in the Annales Mycologici **2**: 28. After considerable investigation he came to the conclusion that Hennings' name should be considered a synonym of Mayr's and that they referred to a species distinct from one that he had at hand which had been recently collected in California by E. B. Copeland. He therefore proposed the name *Gymnosporangium aurantiacum* for his species. Later on Sydow obtained some of Hennings' material and made out that the form described as *Phragmidium Libocedri* was identical with his *Gymnosporangium aurantiacum*. The writer has also examined original material of both these collections and finds this to be the case. The older specific name of the species is *Libocedri* and since Mayr's name is a *nomen nudum* there is nothing to prevent the combination *Gymnosporangium Libocedri* (Henn.) as here proposed. Sydow's specific name *aurantiacum* could not stand in any event as there is a *Gymnosporangium aurantiacum* of Chevallier, Fl. Env. Paris **1**: 424. 1826.

Key to the telia

Telia appearing on galls.		
Galls globoid or reniform.		
Telia pulvinate, low, inconspicuous......	*Sabina barbadensis* *Sabina bermudiana* *Sabina virginiana*	*G. bermudianum* (Farl.) Earle. (Seym. & Earle, Econ. Fungi *249*. 1893.)
Telia terete.		
Telia cylindrical or cylindrical-acuminate, golden-brown...	*Sabina virginiana*	*G. Juniperi-virginianae* Schwein. (Schr. Nat. Ges. Leipzig **1**: 74. 1822.)

Telia somewhat conical, chestnut-brown........	*Sabina virginiana*....	*G. floriforme* Thaxter.
Telia laterally compressed.		
Telia thick, wedge-shaped, chestnut-brown..	*Sabina virginiana*	*G. globosum* Farl. (Anniv. Mem. Boston Soc. Nat. Hist. 34. 1880.)
Telia thin, irregularly flattened, light chestnut-brown..........	*Sabina utahensis* *Sabina monosperma*	*G. durum* Kern. (Bull. Torrey Club 34: 460. 1907.)
Galls very irregular, usually elongated and knot-like (occasionally globoid) telia wedge-shaped, chestnut-brown........................	*Sabina scopulorum*	*G. Betheli* Kern. (Bull. Torrey Club 34: 461. 1907.)
Telia appearing on gradual swellings of the branches.		
Telia terete.		
Telia stout, brownish yellow, spores 2-celled...............	*Juniperus communis* *Juniperus sibirica*	*G. clavariaeforme* (Jacq.) DC. (Fl. Fr. 2: 217. 1805.)
Telia slender, orange-yellow, spores 2–5-celled........	*Chamaecyparis thyoides*	*G. Ellisii* (Berk.) Farl (Ellis, N. Am. Fungi *271*. 1879.)
Telia cristiform, orange-yellow, spores 2–3-celled........................	*Sabina utahensis* *Sabina monosperma* *Sabina pachyphlaea*	*G. speciosum* Peck. (Bot. Gaz. 3: 217. 1879.)
Telia hemispherical or applanate.		
Telia chocolate-brown, spores 2-celled, pedicels terete.........................	*Juniperus sibirica*	*G. junipernium* (L.) Mart. (Fl. Crypt. Erlang. 333. 1817.)
Telia orange-brown, spores 2-celled, pedicels carotiform.....................	*Sabina virginiana* *Juniperus communis* *Juniperus sibirica*	*G. germinale* (Schwein.) Kern.
Telia reddish brown, spores 2-celled, pedicels terete.........	*Sabina virginiana*	*G. Nidus-avis* Thaxt. (Bull. Conn. Exper. Sta. 107: 3. 1891).

Telia chestnut-brown, spores 2–4-celled, pedicels terete.................... *Chamaecyparis thyoides* G. *Botryapites* (Schwein.) Kern.

Telia appearing on the young branches or leaves, with no, or only slight, enlargements.

Telia usually causing fasciation of the branches.

Telia reddish brown, spores 2-celled, pedicels terete.......*Sabina virginiana* G. *Nidus-avis* Thaxt. (Bull. Conn. Exper. Sta. 107 : 3. 1891.)

Telia cinnamon-brown, spores 2-celled, pedicels terete..... *Sabina scopulorum*
Sabina pachyphlaea
Sabina virginiana G. *Nelsoni* Arth. (Bull. Torrey Club **28** : 665. 1901.)

Telia orange-yellow, spores 2–5-celled, pedicels terete *Chamaecyparis thyoides* G. *Ellisii* (Berk.) Farl. (Ellis, N. Am. Fungi *271*. 1879.)

Telia chiefly on the leaves or green stems

Telia hemispherical, chocolate-brown, spores 2-celled.......*Juniperus sibirica*......G. *Davisii* Kern.

Telia tongue-shaped, chestnut-brown, spores 2-celled..... *Sabina virginiana* *Sabina sabinoides* G. *exiguum* Kern.

Telia pulvinate, reddish brown

Teliospores 2–5-celled, pedicels terete......................*Libocedrus decurrens*...G. *Libocedri* (Henn.) Kern.

Teliospores 2-celled, pedicels carotiform.............*Sabina utahensis* G. *inconspicuum* Kern. (Bull. Torr. Club. **34** : 463. 1907.)

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